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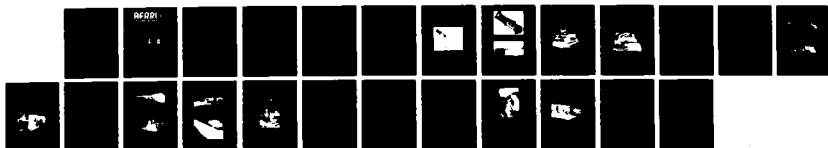
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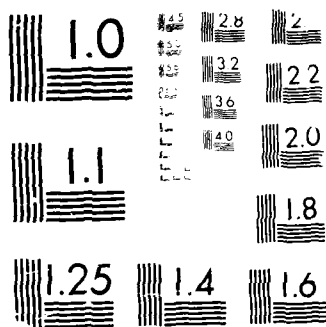
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## TECHNICAL REPORT

### Cleanup of Johnston Atoll missile launch facility

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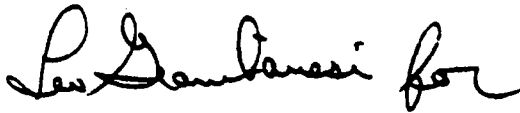
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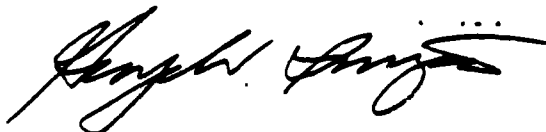
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GEORGE N. CATRAVAS, Ph.D., D. Sc.  
Chair of Science

A handwritten signature in cursive script, appearing to read "George W. Irving, III".

GEORGE W. IRVING, III  
Col, USAF, BSC  
Director

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FIELD	GROUP	SUB GR														
19. ABSTRACT (Continue on reverse if necessary and identify by block number) Johnston Atoll, a remote test site in the Pacific Ocean, was used in 1958 and 1962 to launch missiles to test high-altitude nuclear detonations. In July 1962, when a missile failed to lift off from the launch pad, a nuclear test device was intentionally detonated to prevent any nuclear yield. Although the launch facility suffered only minor damage, it was contaminated with plutonium from the test device. A cleanup operation was immediately conducted, but much of the contamination could not be removed. Instead it was fixed in place by paint, asphalt, concrete, and clean soil. Within 3 months of the launch failure, the facility was again in operation under strict radiological control. No nuclear tests were conducted from the site after 1962, but Launch Emplacement Site 1 was used for missile launches until it was decommissioned in 1977.  In 1980, a long-range program was developed to remove the contaminated material from the test site. In 1984, funds became available to transport the contaminated material to a Federal radioactive-waste																
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disposal site. The waste disposal project involved the dismantling of structures remaining on the site, decontaminating several concrete pads, determining the level of contamination on the debris, preparing and packaging the debris for shipment, and transporting the contaminated material to an authorized waste disposal site. Because the operation involved sea and land transport of a large volume of plutonium-contaminated material, it had the potential of becoming controversial. However, in-depth planning and extensive coordination with appropriate agencies enabled the operation to proceed without incident. This report addresses the planning process, cleanup options considered, instrumentation and measurement techniques, and personnel radiation safety practices. Included are a brief background of the situation, a summary of the planning phase and regulatory guidelines, detailed description of the operation, and discussion of some of the unique circumstances and relevant problems encountered during this project.

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## BACKGROUND

Johnston Atoll is a small group of four islands about 800 miles southwest of Hawaii (Figure 1). The main island, Johnston Island (Figure 2), is about 2 miles long and 0.75 miles wide. The other three islands are smaller and are used mainly as wildlife refuge areas. The atoll has been under United States military control since the early 1930's and is currently administered by the Defense Nuclear Agency (DNA) of the Department of Defense. In 1962, during the testing of high-altitude nuclear detonations, a missile failed at lift-off. To prevent any nuclear yield, the test device was command-detonated, resulting in plutonium contamination of the launch site. Although no nuclear tests were conducted after 1962, the facility was operated under strict radiological controls until decommissioned in 1977.

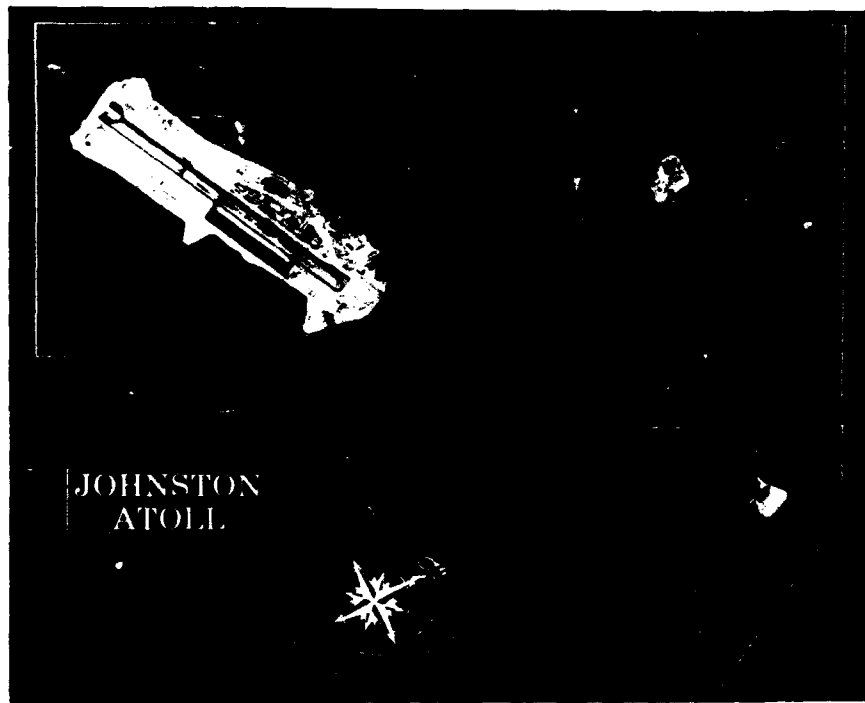


Figure 1. Islands of Johnston Atoll

When the launch facility was deactivated, almost all the missile components were decontaminated and removed from the site. However, the remaining structures could not be decontaminated economically. Included in these structures were the launch erector base, missile shelter building, two large steel revetments, fuel tank, liquid oxygen tank, and the launch pad itself (Figure 3). The launch pad was approximately 138 feet long by 25 feet wide and up to 1 foot thick in some sections. Partially covering the launch pad was the missile shelter building, which was a barnlike structure resting on steel wheels guided by typical railroad tracks. The building consisted of a steel frame covered by honeycomb panels of metal sheet and cardboard spacers. Before a missile was launched, the shelter was driven back about 100 yards; the missile was then raised to the vertical position and fired.

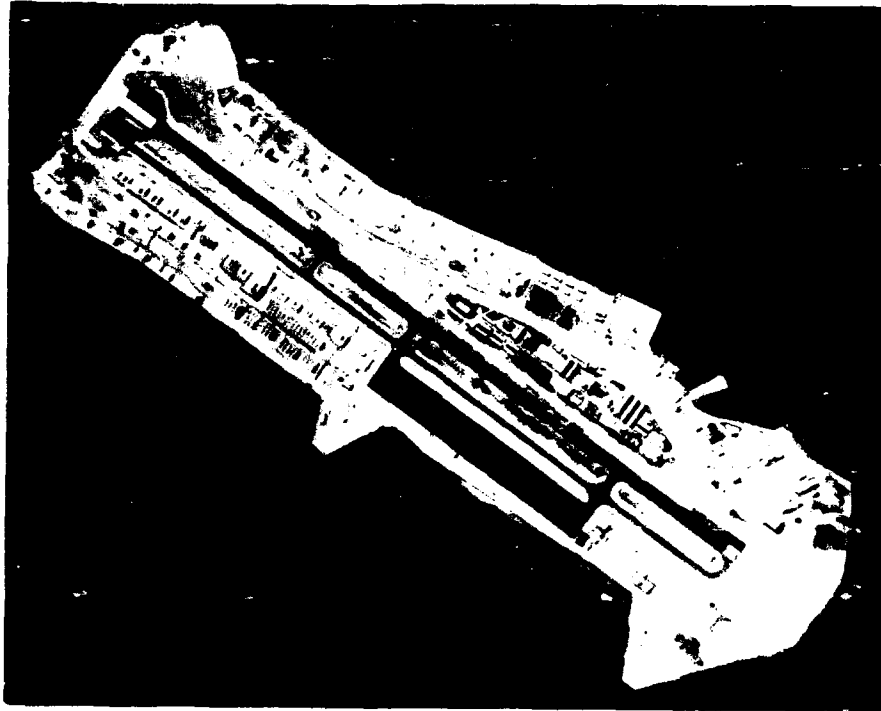


Figure 2. Johnston Island, main island of Johnston Atoll

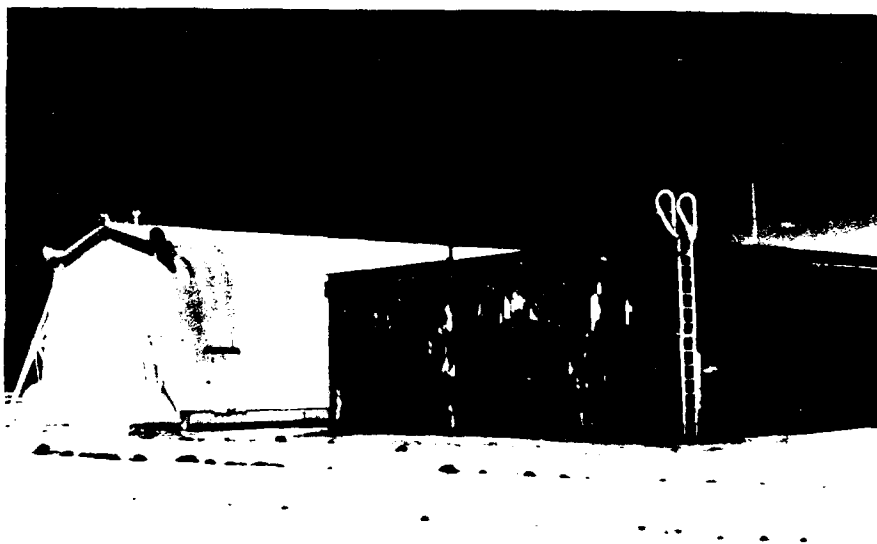


Figure 3. Missile shelter building (background) and steel blast revetments (foreground)

On either side of the moveable missile shelter were revetments constructed of steel piling and thick steel roof plate covered with asphaltic material. The interior and exterior walls were about 4 feet apart, and the space between was filled with aggregate coral. These revetments stored control and diagnostic missile equipment and protected vehicular trailers (which also stored missile equipment) from the blast and heat of the missile launches. Situated near the revetments about 5 feet below grade were the large fuel tank and liquid oxygen tank (Figure 4). The tanks were mounted on concrete pads surrounded by embankments constructed of loose gunite concrete. Also on the site were four 28,000-gallon water tanks (installed after the launch failure); several small concrete pads; and arrays of cable trenches, conduits, metal piping, and electrical cables.



Figure 4. Below-grade liquid oxygen tanks and 28,000-gallon water tanks

During the years the facility remained in use, missile launches and the harsh ocean atmosphere chipped and degraded the paint used to fix the contamination in place. In addition to routine maintenance of the facility, radiological safety procedures required frequent collection of the paint chips and repainting of the surfaces to ensure that the contamination remained fixed. When the site was decommissioned and the majority of missile components were removed, general maintenance at the site was discontinued, necessitating an increase in the radiological maintenance of the facility.

By 1980, there had been significant deterioration of the metal structures at the launch site. Concerns were raised that a strong typhoon might destroy the facility and redistribute the contamination to uncontrolled areas. To protect against further damage from severe weather conditions, the two large steel revetments were dismantled and placed inside the moveable missile shelter (Figure 5). At that time, a comprehensive radiologic survey was completed to determine the extent of contamination. Most of the contamination was fixed to the steel revetments, the doors of the moveable shelter building, and the launch pad. It consisted mainly of plutonium isotopes and an americium impurity (americium-241) typically present with plutonium. The americium-241 impurity is a daughter product of plutonium-241, which decays with a 13.2-year half-life. The primary radiations from these contaminants were alpha particles, characteristic X rays from the most abundant plutonium isotope (plutonium-239), and 60-keV gammas from the americium-241. Because the photon radiation was low and did not have much penetration ability, the major health hazard was from the intake of alpha-emitting plutonium and americium isotopes.



Figure 5. Remains of steel revetments stored in missile shelter building

#### PLANNING

With the completion of the survey, several options for decontamination were considered. Among these were entombing the entire launch facility in concrete, dismantling the facility and storing the debris locally on Johnston Atoll, and dismantling the facility and transporting the waste to a disposal site in the

continental United States. The final option was favored because it would reduce the need for further maintenance and radiologic controls at the site. Also, this option would enable the soil cleanup to proceed, allowing more efficient use of the very limited land space on Johnston Island. A disposal permit was requested and granted from the Department of Energy, and an environmental assessment was performed. It was concluded that packaging the debris and transporting it from Johnston Atoll to the continental United States storage site would have no significant impact on the environment.

A comprehensive operations plan was then developed, which exactly outlined how the cleanup operation would be accomplished and indicated the time allotted for each segment of the project. Responsibilities for logistical, radiation safety, financial, and transportation aspects of the project were designated in the operations plan. Overall management of the project was the responsibility of the DNA Health Physicist, who also served as the Radiation Safety Officer for the operation. Funding was obtained from the Department of Defense Environmental Restoration Fund, which is comparable to the Environmental Protection Agency's "super fund." Personnel to perform the dismantling, packaging, and transport were provided from several sources. DNA provided military health physicists to assist the Project Officer by serving as Assistant Radiation Safety Officer, and enlisted members of the U.S. Air Force Military Airlift Command provided radiation safety technician support. The Air Force personnel were trained as explosive ordnance disposal specialists, with radiation safety as a collateral duty. The actual disassembly of the facilities and the packaging of debris were performed by the Johnston Atoll operating contractor with assistance from a subcontractor, who removed the contaminated concrete surfaces. The Military Sealift Command, which is controlled by the Military Traffic Management Command, transported the debris from Johnston Atoll to the continental United States. Finally, a commercial trucking company provided the overland transportation to the storage site.

There was continuous coordination with the agencies mentioned above (Department of Energy, Military Sealift Command, Military Traffic Management Command, USAF, etc.) before and during the operation. In addition, coordination was effected with appropriate elements of the Environmental Protection Agency and state radiological safety offices. A public affairs plan also was developed to provide prompt and accurate response to questions from the public. This painstaking planning and coordination were necessary to ensure that all state and federal laws and regulations were followed in all phases of the operation.

#### REGULATIONS OF DEPARTMENT OF TRANSPORTATION AND NEVADA TEST SITE

Based on the measurements of the 1980 radiologic survey, it was presumed that most of the contaminated material would fall under the Department of Transportation (DoT) category of low specific activity (LSA) material. According to DoT, plutonium-contaminated material may qualify as LSA in one of two ways. First, LSA material may be nonradioactive material externally contaminated with an activity of less than  $100 \text{ nCi/cm}^2$  when averaged over a square meter. Second, plutonium may be uniformly distributed throughout a volume of nonradioactive material if the average activity is less than  $100 \text{ nCi/g}$ . Because LSA materials are

considered inherently safe to transport, they are excepted from the DoT requirements of specification packaging, marking, and labeling if transported as an exclusive-use shipment in strong, tight containers so that there are no leakage of radioactive materials and no shifting of lading under normal conditions of transportation. A shipment is for exclusive use if the transport conveyance is used solely by a single consignor. The conveyance can be a freight container for highway transport, or a hold or defined deck area for ship transport. In addition, there must be no significant surface contamination on the packages and no loose radioactive material in the conveyance. Finally, the transport vehicle must bear the yellow-black-and-white RADIOACTIVE placard, and each package must be labeled "Radioactive - LSA." Any material that did not meet the LSA criterion was expected to be packaged in DoT Type A shipping containers (specified type 7A 55-gallon drums). The DoT criterion for use of a Type A container is that the activity in each package must be less than 2 mCi. If a material was so "hot" that it exceeded the criterion for the Type A container, then it would be packaged in drums and stored in a secure place on Johnston Island, pending ultimate disposal at a DOE waste isolation pilot plant. In addition to the DoT regulations, the contaminated material had to meet the Nevada Test Site (NTS) criterion for low level waste. That is, activity in each container had to be less than 100 nCi/g, where the mass includes all materials buried.

## EXECUTION

### CONCEPT OF OPERATION

The basic assumption of this operation was that all material on the site was contaminated, until measurements proved otherwise. Before the disassembly began, the structures and equipment left on the site were evaluated to determine if they could be salvaged. Several items (such as the fuel tank, liquid oxygen tank and water tanks, and copper cabling) were still serviceable, and their decontamination would be relatively easy. However, most of the structures were severely rusted and corroded, and it was considered more economical to dispose of them than to attempt their decontamination.

To ensure that the nonsalvageable contaminated materials met the DoT and storage-site requirements, the structures on the Launch Emplacement Site 1 (excluding the concrete pads) were first disassembled and cut into workable sizes (Figures 6 and 7). When possible, the debris was cut into pieces about 6 feet by 8 feet to conserve space in the freight containers. Because there were so many different types of debris (pipes, cabling, ladders, railroad ties, etc.), the sizes of the cut pieces varied greatly. Each piece was then cleaned and painted. The debris was painted to effectively fix any remaining contamination in place, meeting the DoT requirement that there be no loose contaminants. The loose Gunit concrete could be broken up into workable pieces and processed in the same manner as the structural debris. However, it was not practical to remove the massive concrete pads. Instead, only the contaminated surfaces were removed through a process called scabbling, in which the top layers were chipped away. That material was then stored in 55-gallon drums. The scabbling process, described below, resulted in rubble whose contamination was uniformly distributed. Before

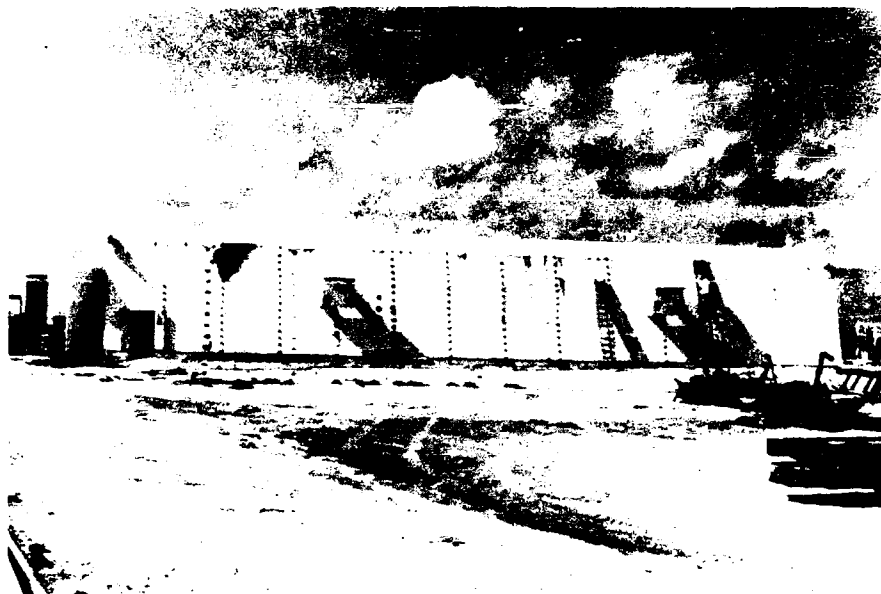


Figure 6. Missile shelter building before disassembly

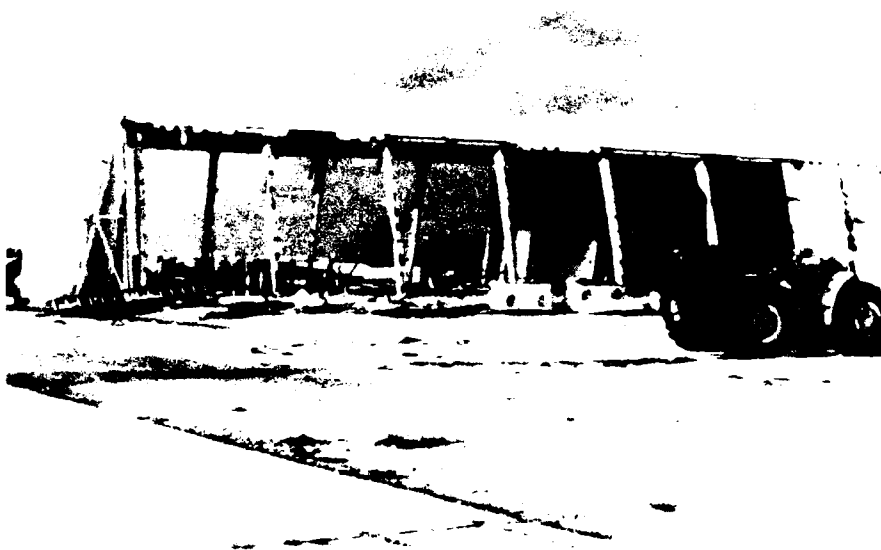


Figure 7. Missile shelter building with panels removed

packaging, all debris was monitored by counting the 60-keV photons from americium-241, using either an intrinsic germanium detector or a sodium iodide detector with a well-defined source-detector geometry.

Structural debris meeting the LSA criteria was loaded onto large (20 feet long by 8 feet wide by 9 feet high) dry-cargo freight containers (Figure 8), and the concrete rubble and any Type A material were loaded into 55-gallon drums. The freight containers were lined with plywood on each of the six surfaces to prevent puncturing of the walls, and were braced to prevent settling or rearrangement of the contents during shipment. These containers served as both package and transport vehicles for the bulk LSA material. One freight container was dedicated to the material packaged in the 55-gallon drums, and for these materials, the freight containers served only as the transport vehicle. Detailed records were kept of the material and the total amount of activity loaded into each container so as not to exceed the DoT or the Nevada Test Site criterion. The freight containers were shipped from Johnston Island to the Naval Construction Battalion Center in Port Hueneme, California, and then were transported by truck to the disposal site at the Nevada Test Site.



Figure 8. Debris being weighed before loaded into freight container at rear

## FLOW PATTERN OF DEBRIS

The missile launch facility was located on the northern shore of Johnston Island, the main island of the atoll. Prevailing winds blew from east to west; residential and most work areas on the island were upwind from the launch site (Figure 9). The layout of the site was organized to establish an efficient flow pattern for the removal of the contaminated materials. The different processing stations were arranged so that they were crosswind of each other. The break area, storage shed, and laundry trailer were all upwind of the contaminated area; a road barrier and open water were downwind of the site.

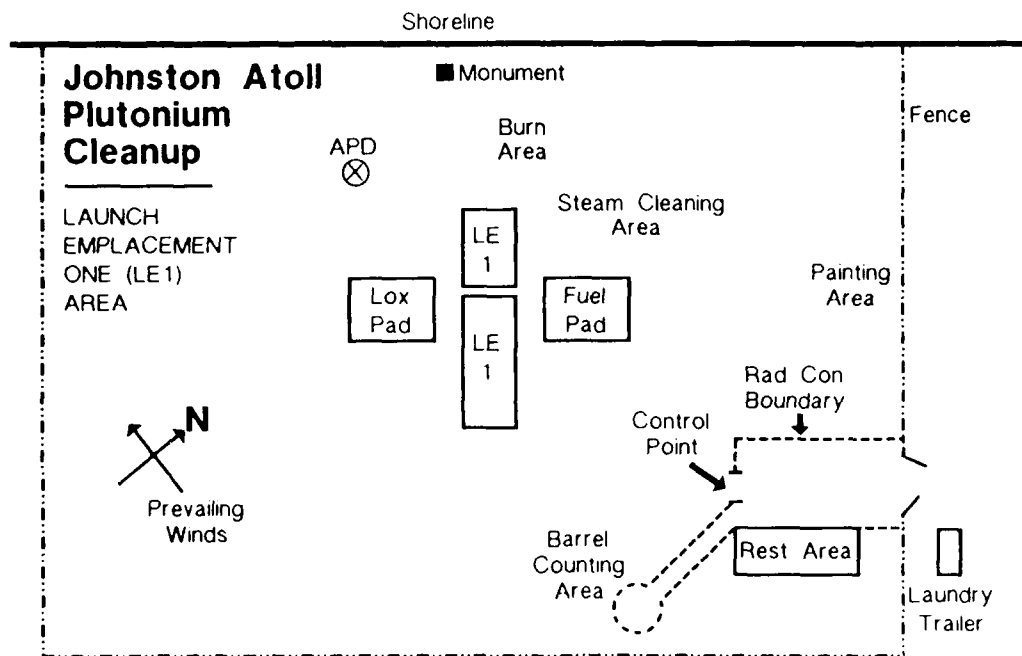


Figure 9. Layout of cleanup site

The first step in the removal process was to reduce the materials to workable sizes. The debris was cut into smaller pieces using acetylene torches, saws, and chipping hammers. After the materials were cut, they were either steam cleaned or rinsed with a high-pressure water hose to remove any loosely bound contaminant, paint, or dirt. The material was then loaded onto a clean pallet and moved to the painting area. At this station, any remaining contamination was fixed in place with a thick coating of black piling paint or white or yellow road-striping paint (which was outdated and not suitable for road use) (Figure 10). After all the exposed surfaces were painted, the materials were sent to the exit hot line for delivery by forklift to the counting site (Figure 11). Before leaving the contaminated area, the debris was smear-monitored to check for loose contamination.



Figure 10. Debris paint area to fix contamination before monitoring



Figure 11. Transporting painted debris from paint area to counting pad

The counting area was about 800 feet east of the launch site and was chosen for its relatively low background radiation. When the pallets reached the counting area, they were laid out in rows (Figure 12), and each piece of debris was numbered (Figure 13). To locate areas with high levels of contamination, a preliminary



Figure 12. Debris laid out in rows at counting area



Figure 13. Numbers painted on each pallet of debris for identification

survey was performed over the surface of each piece with a modified FIDLER (field instrument for detection of low-energy radiation). The FIDLER used for screening had a 2-inch-diameter sodium iodide crystal connected to an analog ratemeter and earphones, and the window was set to detect the 60-keV photons from the americium-241. When "hot spots" were located, they were marked with spray paint and counted separately. The activity on each piece (and hot spot) was measured using the germanium detector (Figure 14) or the backup sodium iodide detector. The counting system is discussed in detail below.

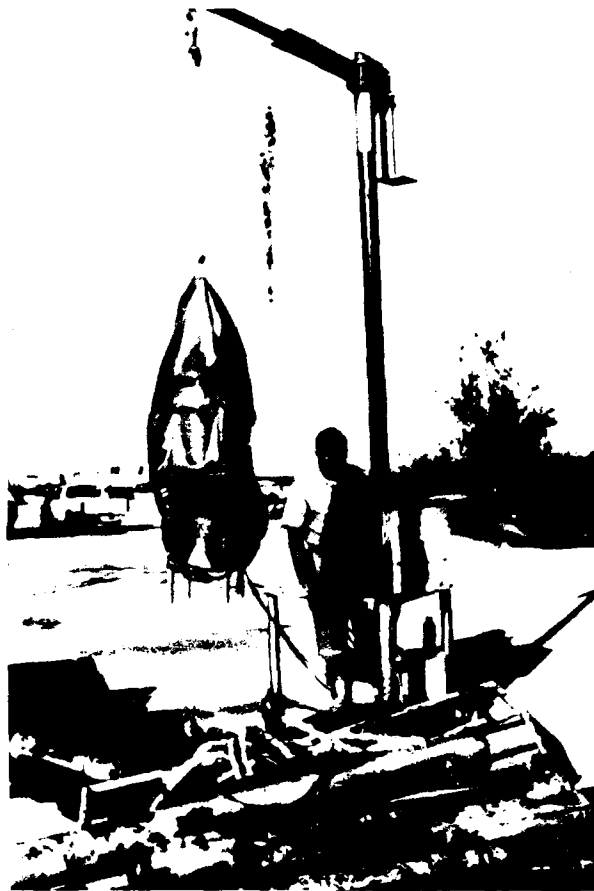


Figure 14. Monitoring pallet of debris with germanium detector system

After counting, the materials that met the LSA criterion were loaded into the freight containers, and the physical dimensions (weight, length, and width) and a brief description of the material were recorded in the packaging logbook.

## DECONTAMINATION OF CONCRETE PADS

As mentioned above, the large concrete pads were decontaminated instead of removed from the site, because the launch pad and the pads beneath the fuel tank and liquid oxygen tank were far too massive. To significantly reduce the waste volume, it was decided to remove only the contaminated surfaces. This was accomplished through the scabbling process, in which the proximate concrete surface was hammered away. The scabbling device had five heads with carbide-tipped nipples that were used to finely chip the concrete surface to about a 7-mm depth. A wooden box enclosed the chipping head to prevent dispersal of contaminated concrete chips and dust. The box was continuously evacuated to a cyclone separator, which deposited the heavier particles into a 55-gallon drum through an HEPA (high-efficiency particulate air) vacuum system. While most of the concrete rubble was removed by the cyclone separator, a small amount (about 5%) remained in the HEPA filter system. The filters were later disposed of in the 55-gallon drums. A Vacublaster was used to decontaminate the cracks and expansion joints in the concrete pads. Before using the Vacublaster on the expansion joints, the joint filler material was removed and disposed of in a 55-gallon drum. The Vacublaster used a narrow nozzle to propel steel shot onto the concrete to wear away a few millimeters at a time. The concrete debris and used steel shot were then vacuumed up by the Vacublaster through the HEPA system. Most of the shot was then recycled by the Vacublaster for continued use. A quantitative assessment of the amount of contamination removed from the pad was obtained through the use of the intrinsic germanium counting system (discussed below in Radiation Measurements section). The pads were monitored after the scabbling and use of the Vacublaster, and these processes continued until the contamination was below the minimum detection limit of the counting system (about  $10 \text{ nCi/cm}^3$ ). After the concrete pads were successfully decontaminated, they were covered with a layer of "clean" dirt to prevent recontamination.

## MEASUREMENTS OF RADIATION

The quantitative measurements were performed using a high-resolution germanium detector coupled to a portable multichannel analyzer. As a backup, a FIDLER with a 13-cm sodium iodide crystal connected to a scaler was used with the multichannel analyzer. (Note that similar systems have been used in other cleanup operations.) The backup FIDLER was needed toward the end of the operation when the preamplifier failed on the germanium detector. Both detectors were used with an 11-inch-long cylindrical collimator so that the field of view was circular and limited to about 35 degrees. The detector in use was suspended from a rope attached to a mobile rig. This was done to reduce the interference from microphonic noise caused by the heavy equipment and aircraft on the nearby runway. To accommodate the wide range of sizes of the contaminated material, the detectors could be adjusted from 1 to 6 feet above the ground. Calibration of the detectors was checked once a day with an americium point source, and background readings were taken at least twice a day (before and after counting). The counting system measured the americium-241 activity per area, and this had to be converted to total transuranic alpha activity from all the plutonium and americium isotopes. The transuranic activity of the Johnston Island plutonium contamination was  $8.7 \pm 2.9$  times the americium-241 activity.

The detector was placed above the center of a piece of debris so that the field of view covered the longest dimension. If this was not possible, either the piece was cut into smaller sections or more than one count was made. When a hot spot was indicated on the debris, the detector was placed above the hot spot so that the field of view encompassed one square meter with the hot spot in the middle. Each piece was counted for 2 minutes, and the material identification number, peak display, and net area counts were recorded on multichannel analyzer minicassette tapes. The taped data were later input and stored along with the packaging data in a Compaq Plus (Houston, TX) computer.

Assessment of the contamination present on the concrete pads was more complicated. The pads were first cleaned with the HEPA vacuum to remove loose contamination, and then a uniform grid survey was performed. This was accomplished by dividing the pads into square blocks, 6 feet by 6 feet, and sequentially numbering each block. Also, hot spots and hot lines (mainly found in the joints) were identified with the FIDLER and numbered separately. The germanium multichannel analyzer counting rig was rolled over the center of each box, and counting was performed as described above. To count the hot spots and hot lines, a steel plate about 1/4-inch thick was placed over the rest of the block so that only the area of interest was counted. Similarly, when the entire block was counted, steel was placed over the hot sections so that they were not included in the counting. The data from each block, hot spot, and hot line were stored in the computer. During the scabbling and Vacublaster operation, a careful tally was kept so that it was known in which drum each section of concrete pad was stored. The total weight in each drum then could be divided by the total activity to determine the activity per gram.

Several 55-gallon drums had been filled with radioactive waste from the many cleanup operations over the years at the site. Included in this waste were hot pieces of coral, americium smoke detectors, and other miscellaneous items. Although this material was already packaged, the amount of activity needed to be assessed. This was done by cutting the bottom 6 inches off a 55-gallon drum and filling it with the contaminated material. The detector was then placed over the drum, and the calculations were performed, considering the material in the drum as a disc source. The material was repackaged in 55-gallon drums, but the amount of transuranic activity contained in each was now known.

#### SCREENING FOR LSA

The amount of activity contained on the different types of debris was carefully measured so that compliance with the DoT regulations could be demonstrated. As discussed earlier, two criteria apply for plutonium-contaminated material to be considered LSA: (a) nonradioactive material that is externally contaminated, with an activity of less than 100 nCi/cm<sup>2</sup> averaged over a 1-square-meter area, and (b) contamination uniformly distributed throughout a volume of nonradioactive material with an average activity of less than 100 nCi/g. Note that the first criterion was applied to the painted structural debris, and the second to the concrete rubble. A screening level of 50% of the DoT standards was chosen to be conservative, that is, 50 nCi/cm<sup>2</sup> for the structural components and 50 nCi/g for the concrete debris. As expected, almost all material met this conservative

screening level. Only one 55-gallon drum had to be shipped as a Type A container, and no waste exceeded the criteria for a Type A container (less than 2 mCi per package).

## PACKAGING AND SHIPPING

All the bulk LSA debris was loaded directly into the reinforced freight containers, and one container was dedicated for the 55-gallon drums. The debris counting data, which had been stored in the computer, were sorted by container number, enabling printout of the contents and weight of each container, as well as the total activity and mass of plutonium contained in each. This was a convenient method of ensuring that each freight container met the Nevada Test Site criterion for low-level waste (this screening level was also set at 50 nCi/g). Before a filled container was moved to the holding area, the door was welded shut and the outside of the container was smear-monitored to check for contamination.

All of the freight containers were placarded, and all but the container with the 55-gallon drums were labeled as radioactive LSA. However, each drum containing LSA material in this freight container was labeled "Radioactive - LSA." A commercial freighter under contract by the Military Sealift Command was used to transport the containers to the Naval Construction Battalion Center. A Radiation Safety Officer accompanied the shipment to monitor the containers in the event of container damage. Radiation measurements of the ship container storage areas were made before loading the containers aboard ship and after the containers were off-loaded. Radiation surveys were also conducted at the Naval Construction Battalion Center port handling facility after the containers were moved to the waste site. The final leg of the journey was made by a trucking company, which was fully certified to transport radioactive materials.

## DISCUSSION

The cleanup described above was an extensive operation requiring resources from many government and civilian organizations. Throughout the project, several logistical and technical challenges were met, and some lessons were learned that may be of interest to others beginning similar operations.

## RADIATION SAFETY

The major radiological danger throughout the operation was the possibility of inhaling alpha-emitting actinide particles. For this reason, strict radiological control procedures were maintained. Full anticontamination clothing and respirators (Figure 15) and full-body monitoring with alpha detectors at the hot line contributed to a successful program. The airborne contamination hazard normally associated with winds was mitigated because of the heaviness of the plutonium contaminant. Air monitors were run continuously at 30, 50, and 100 meters downwind of the site. These read as high as 50 fCi/m<sup>3</sup> averaged over a 24-hour period. As expected, they gave high readings when there was activity that involved mixing up the debris (such as torching, cutting, and scabbling) and low readings (tens of fCi/cm<sup>3</sup>) when there was not much activity. The air monitors upwind of the site typically read 10-50 fCi/cm<sup>3</sup>.



Figure 15. Removing respirators at contamination hot line: Note use of full anticontamination clothing

All personnel were monitored with LiF dosimetry to document the external exposure received during the project. A 24-hour urine specimen for each person was taken for radioanalysis before working at the site and after conclusion of the job. The thermal luminescent dosimeters and the urine samples were processed by the Air Force at the Occupational Environmental Health Laboratory. The results indicated that no external or internal doses were received as a result of the operation.

The laundry trailer was used to return uncontaminated and contaminated anticontamination suits to use. After laundering, each piece was monitored with alpha detectors to determine if it was radiologically clean. The washing machine was then smear-monitored before another load was started, and the water from the washer was piped back into the controlled area.

## HEAT PREVENTION PROGRAM

Most of the heavy labor was done in full anticontamination suits, including full-face respirators, which caused serious concern for heat-related injuries. Therefore, a heat prevention program was implemented and followed conscientiously. A bottsball thermometer was used to indicate the heat conditions. All personnel wearing the protective clothing were briefed on the nature of heat illness, means of notifying personnel when the temperature is critical, proper response to be taken for various temperature conditions, and appropriate first aid for a heat-related casualty. Intake of water and the work-rest cycles were based on the bottsball temperature (Figure 16). These measures proved to be effective, as there were no heat-related injuries during the operation.



Figure 16. Workers resting at rest area outside contamination hot line before and after working inside site

## DECONTAMINATION OF EQUIPMENT

Several pieces of equipment were salvaged from the site, including fuel tanks, liquid oxygen tanks, water tanks, and some copper cabling. The equipment was decontaminated by steam cleaning the outer surface and then surveying and smear-monitoring it to ensure that all contamination was removed. If the contamination had not been removed, the procedure was repeated. Equipment used in the operation (such as forklifts), which had to be removed from the controlled area, were treated similarly. They were surveyed, smear-monitored, and released after negative results. If contamination was indicated, the equipment was steam-cleaned and checked again.

## PACKAGING AND COUNTING

A unique aspect of this operation was the use of freight containers as both package and transport vehicle. This dual use of the containers was considered the most efficient method of transporting the large pieces of steel debris, which made up most of the contaminated material. An added advantage of these freight containers was that because of their low cost, they were disposed of with their contents at the waste-disposal site.

Novel techniques were also used to measure the activity of all the debris packaged and transported from Johnston Atoll. This was done through several modifications of a typical counting system. Debris with essentially uniform surface contamination, volume contaminated debris, and debris considered as a disc source were all effectively monitored to determine the total transuranic activity.

## COMPUTER

A Compaq Plus computer was used with Symphony software (Lotus, Cambridge, MA) to store, reduce, and analyze the data collected. After an initial period of familiarization with the computer and software, the computer became an invaluable tool and time-saving device. Data for each shipping container were readily available, and total amounts of volume and activity could be easily retrieved from the data base. In fact, the computer was used to produce the manifests for the shipping documents.

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